ARJUNA

JEE

⇒ Test Ka syllabus 17 July → Complete moleconcept Chapter

LECTURE - 03

Atomic structure

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Q. Find out the ratio of volume of atom and volume of nucleus is

1 minutes

A 10^{+18}

B 10^{+13}

C 10^{+15}

D 10^{+3}

$r_{atom} = 10^{-10} m = 10^{-8} cm$

$r_{Nu^-} = 10^{-15} m = 10^{-13} cm$

$\frac{V_{atom}}{V_{Nu^-}} = \frac{\frac{4}{3}\pi (10^{-10})^3}{\frac{4}{3}\pi (10^{-15})^3}$

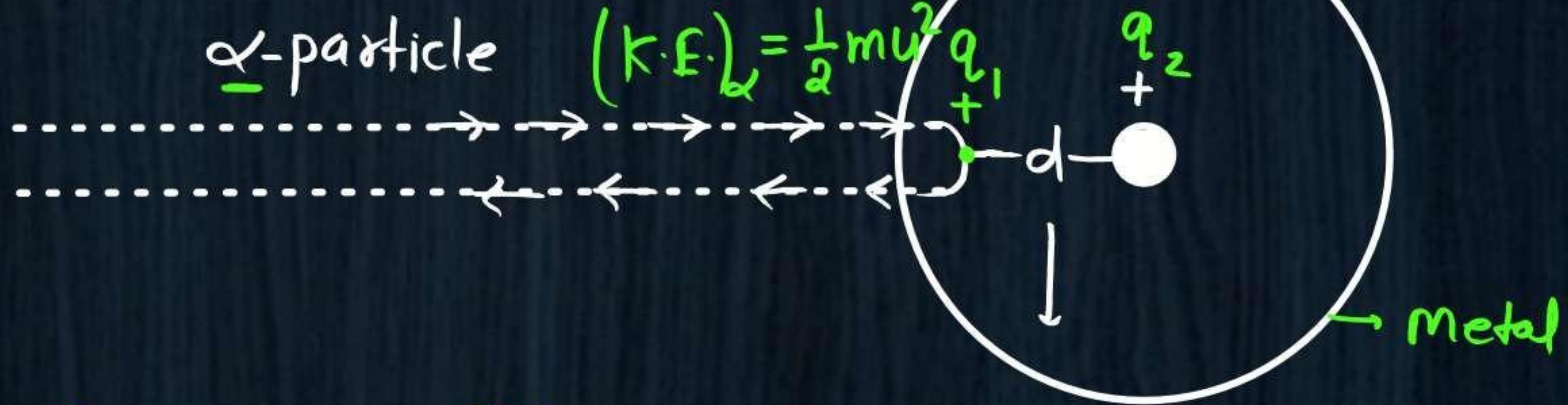
$\frac{V_{atom}}{V_{Nu^-}} = \frac{10^{-30}}{10^{-45}} = 10^{+15}$

Closest distance b/w α-particle and nucleons of atom (d)

$\alpha = \left({}_{2}He^{4}\right)^{+2}$

$F_c = K\dfrac{q_1 q_2}{r^2}$

$P.E = \dfrac{K q_1 q_2}{r}$



$(K.E)_\alpha = P.E = \dfrac{K \cdot q_1 q_2}{d}$

distance of closest approach

$$\boxed{d = \dfrac{K \cdot q_1 q_2}{(K.E)_\alpha}}$$

where → q_1 = charge of α-particle $\left({}_{2}He^{4}\right)^{+2} = 2e^- = 2\times1.6\times10^{-19}\,C$

q_2 = Charge of Nucleous $(Z) = Z\times e$

Where = Z = Atomic No. of metal

$\Rightarrow K = \text{Const} = 9 \times 10^9$

$C_{SD} = 4$

distance of closest approach (d) = $\frac{K \cdot q_1 q_2}{(K.E.)_\alpha}$

$q_1 = 2e^-$

$q_2 = Z \times e$

↓

Atomic No. of metal

$K = \text{Const} = 9 \times 10^9$

$(K.E.)_\alpha = \frac{1}{2} m_\alpha u_\alpha^2$

Q. α-particle travell in x joule K.E, Calculate distance of closest approach, If Na-metal foil used in scattering Exp.

(a) $\frac{KZe^2}{x}$

✓ (b) $\frac{K2Ze^2}{x}$

(c) $\frac{KZe}{x}$

(d) $\frac{2KZe}{x}$

Solⁿ ⇒

$$d = \frac{K q_1 q_2}{(K.E.)_\alpha}$$

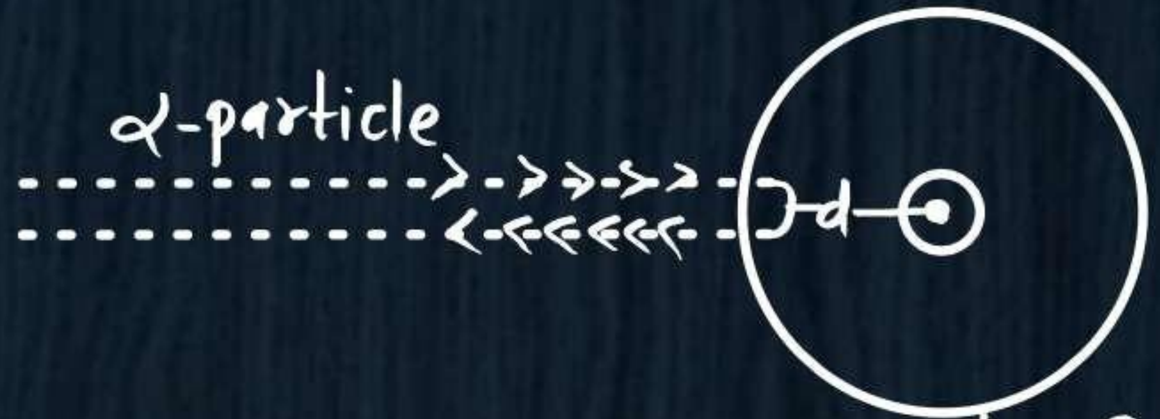
$q_1 = 2e$

$q_2 = Ze$

$$= \frac{K \cdot 2e \times Ze}{x}$$

$$= \frac{2KZe^2}{x}$$

Q



↳ Ca-atom metal foil.

$_{20}Ca^{40}$

Select the correct value of K.E. of α-particle

(a) $\frac{40ke^2}{d^2}$

(b) $\frac{40ke}{d}$

✓ (c) $\frac{40ke^2}{d}$

(d) None of these

$q_1 = 2e^-$

$q_2 = Ze = 20e$

Solⁿ ⇒ $d = \frac{K q_1 q_2}{(K.E.)_\alpha}$

$d = \frac{K 2e^- \times 20e}{(K.E)_\alpha}$

$(K.E.)_\alpha = \frac{40ke^2}{d}$

N-atom ⇒ $_{7}N^{14}$

$P = 7$ (Atomic No = No. of proton)

$Z = P$

$+7 = Z \times e$

$P = e = 1.6 \times 10^{-19}$

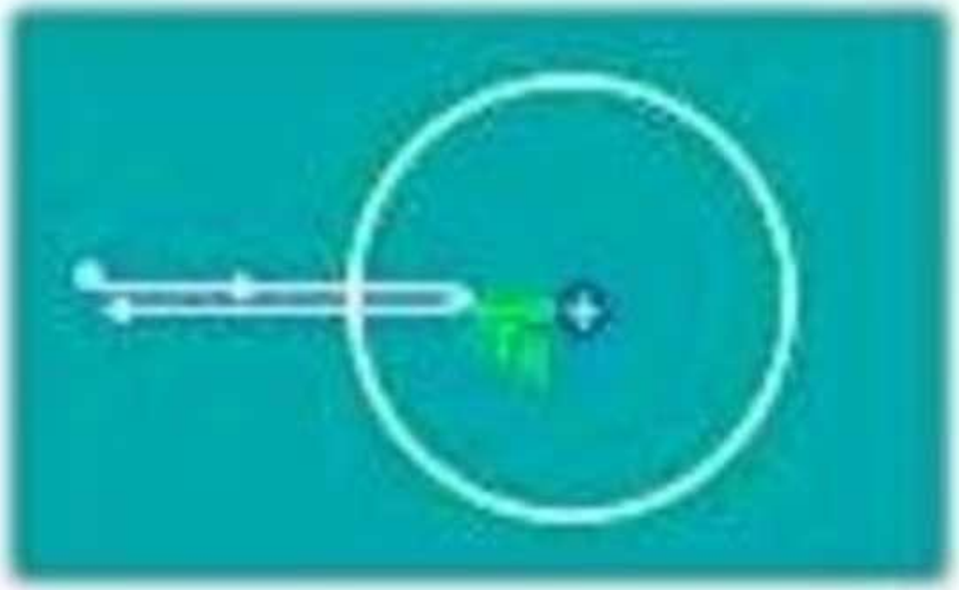
$= 7 \times 1.6 \times 10^{-19}\, C$

$Z \times e = Ze$

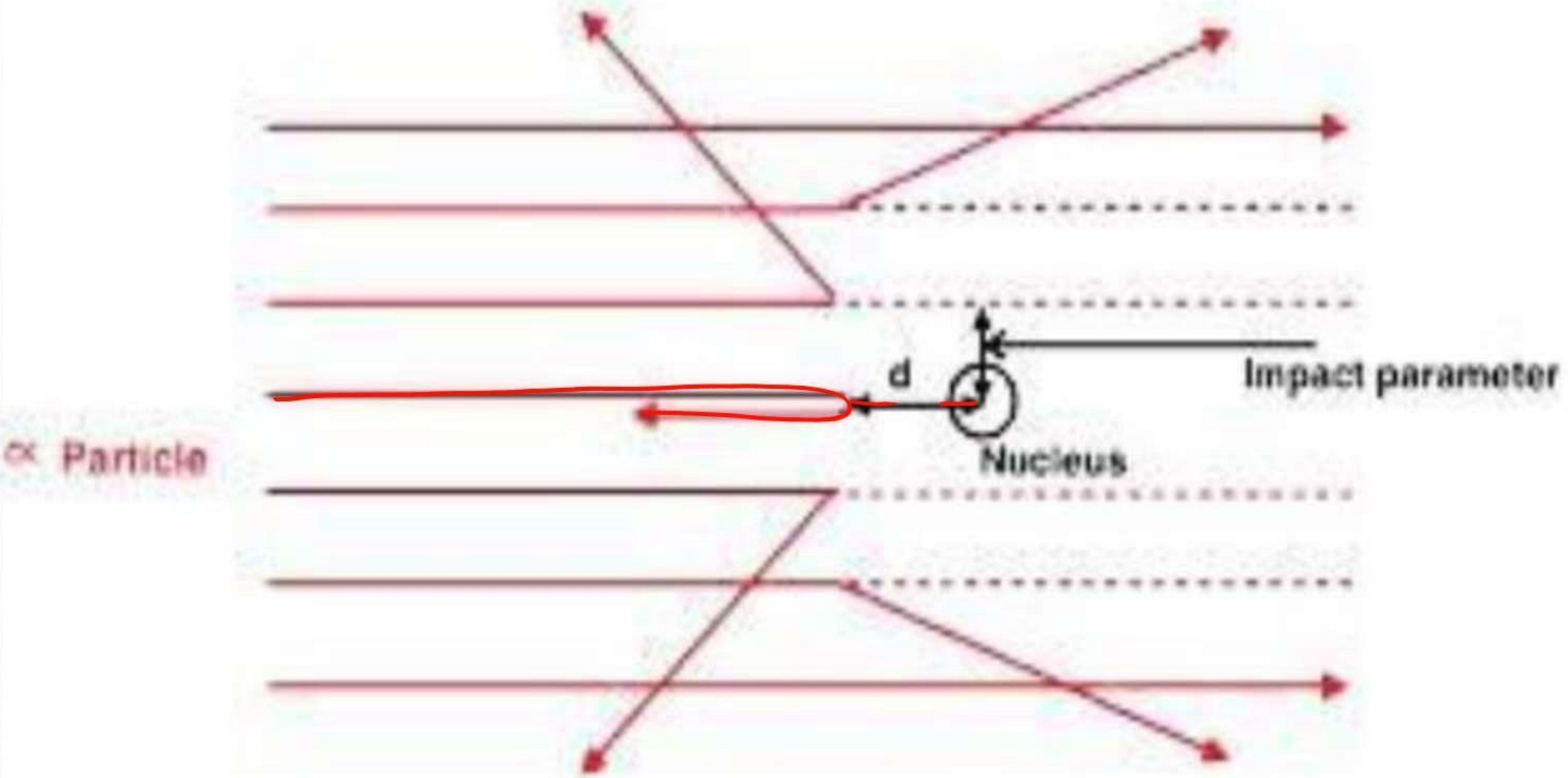
- Distance of closest approach is the minimum distance between α-particle and centre of nucleus just before it reflects back by 180°
- When the distance between α-particle and the nucleus is equal to the distance of the closest approach (r_0), the α-particle comes to rest. At this point or distance, the kinetic energy of α-particle is completely converted into electric potential energy of the system.

$$\frac{1}{2}mv^2 = \frac{1}{4\pi\varepsilon_0}\frac{Ze^2}{r_0}$$

$$r_0 = \frac{1}{4\pi\varepsilon_0}\frac{2Ze^2}{mv^2}$$



- Obviously, the radius of nucleus must be smaller than above value.



α Particle
d
Impact parameter
Nucleus

Q. With what velocity should an α-particle travel towards the nucleus of a copper atom so as to arrive at a distance 10^{-13} m from the nucleus of the copper atom ?

[1997 (C), 3M]

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Atomic Number of an Element (z)

Total number of protons present in the nucleus = Total number of electrons present in the atom

Mass number of an element = Number of protons + Number of neutrons.

Mass number → A

X ← Symbol of element

Atomic number → Z

Neutron atom → Z = p = e

e.g., $^{23}_{11}Na$, $^{35}_{17}Cl$ and so on.

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Terms associated with elements

- **Isotopes**: Atoms having same number of protons.

  ↳ same Atomic No. (Z)

  ↳ but different Atomic Mass (A)

  Ex → (a) $_1H^3$ (b) $_1H^2$ (c) $_1H^1$

  Ex → (a) $_{17}Cl^{35}$, $_{17}Cl^{37}$

- **Isobars** : Elements having same mass number

  ↳ same Atomic Mass No. (A)

  ↳ different Atomic No. (Z)

  Ex → $_1H^3$, $_2He^3$

  Ex → $_6C^{14}$, $_7N^{14}$

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Q ($_1H^3$, $_2He^3$) ✗   ($_{17}Cl^{35}$, $_{17}Cl^{37}$) ✗   ($_6C^{13}$, $_7N^{13}$) ✗

($_4Be^9$, $_5B^{11}$) ✓   ($_{15}P^{31}$, $_{16}S^{32}$) ✓ ,   ($_{29}Cu^{63}$, $_{29}Cu^{65}$)

Q→1 How many pair follows isotopic properties (isotopes) = (2)

isotopes → same Z
but different 'A'

Q-2→ How many pairs are isobars = 2

Q-3⇒ How many pairs are not isotopes and isobars = 2

Terms associated with elements

- **Isotones** : Element having same number of neutrons (A – Z).

  ↳ same No. of neutrons (n)

  $_{Z}X^{A=(p+n)}$, Z → p

  $n = A - Z$

  Ex → $_{1}H^{3}$, $_{2}He^{4}$ → isotones

  n = (2) (2)

- **Isoelectronic** : Species/elements having same number of electrons

  ↳ same No. of electron

  Ex = CO , N_2

  CO: 6+8 = 14 ; N_2: 7+7 = 14

Q Select the correct pair of isotones

(a) × ${}_{1}H^{2}$ ${}_{1}H^{3}$

× (b) ${}_{6}^{}C^{12}$ (6), ${}_{6}C^{13}$ (7)

✓ (c) ${}_{6}C^{14}$ (8), ${}_{8}O^{16}$ (8)

14 − 6 = 8

16 − 8 = 8

(d) ${}_{7}N^{14}$, ${}_{6}C^{14}$

Q select isoelectronic species.

e = p = Z

(a) CO_2, CO ×

(b) CO, NO_2 ×

✓ (c) CO_2 NO_2^+

6+16 = 22 7+16−1 = 22

(d) None of these

CO_2

↓

6 + 8×2 = 22

$NO_2^{\pm}$

7 + 2×8 − 1 = 6 + 16 = 22

Terms associated with elements

- **Isosters** : L Species having same number of atoms and elctrons
  - same No. of e^-
  - same No. of atom

$Ex \rightarrow N_2, O_2^{+2}$

$7+7 \quad 8+8-2$

$e^- = 14, \; e^- = 14$

- **Isodiaphers** : elements having same number of |N – Z| or |A –2Z|
  - same No. of $(n-P)$ or $n-Z$

$A-Z-Z = |A-2Z|$

$_Z X^{A\,(P+n)}$

$Z\,(P) \quad n = A-Z$

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Q. select the correct pair of isosters — same No. of atoms; same No of e^-

(a) N_2, O_2 ✗

(b) N_2^+, N_2^- — ✗

(c) CO_2, NO_2 — ✗

✓ (d) CO, N_2

$6+8 = 14$ $7+7 = 14$

Q select pairs of isodiaphers

× (a) $_{10}Ne^{20}$, $_{20}Ca^{20}$

$A-2Z = 0$ $\quad 20-2\times 20 = -20$

× (b) $_{1}H^{1}$, $_{2}He^{4}$

$A-2Z$ $\quad 1-2=-1$, $\quad 4-4=0$

× (c) $_{1}H^{3}$, $_{2}He^{4}$

$3-2=+1$, $\quad 4-2\times 2=0$

✓ (d) None of these

isodiaphers $= |A-2Z|$

$_{Z}X^{A}$

Terms associated with elements

- **Paramagnetic** : Species having non-zero unpaired electron

- **Diamagnetic** : Species having zero unpaired electron

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Q. The sun of the number of neutrons and proton in the isotope of hydrogen is

[1986, 1 M]

A 6 ✓

B 5

C 4

D 3

p+n (A)

H — $_{1}H^{1}$ = 1

H — $_{1}H^{2}$ = 2

H — $_{1}H^{3}$ = 3

Total = 6

$_{Z}X^{A\,(p+n)}$

Z (p)

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Q.

Elements of the mass number but of different atomic number are known as isobars

[1983, 1M]

Q → sum of total Number of neutrons in all isotopes of H-atoms — IIT-JEE = 2021

Sol^n

$n = A - Z$

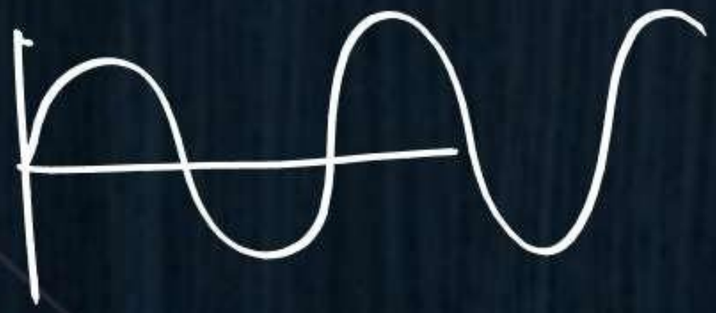
H —
- $_1H^1 \rightarrow 1-1 = 0$
- $_1H^2 \rightarrow 2-1 = 1$
- $_1H^3 \rightarrow 3-1 = 2$

$0+1+2 = 3$

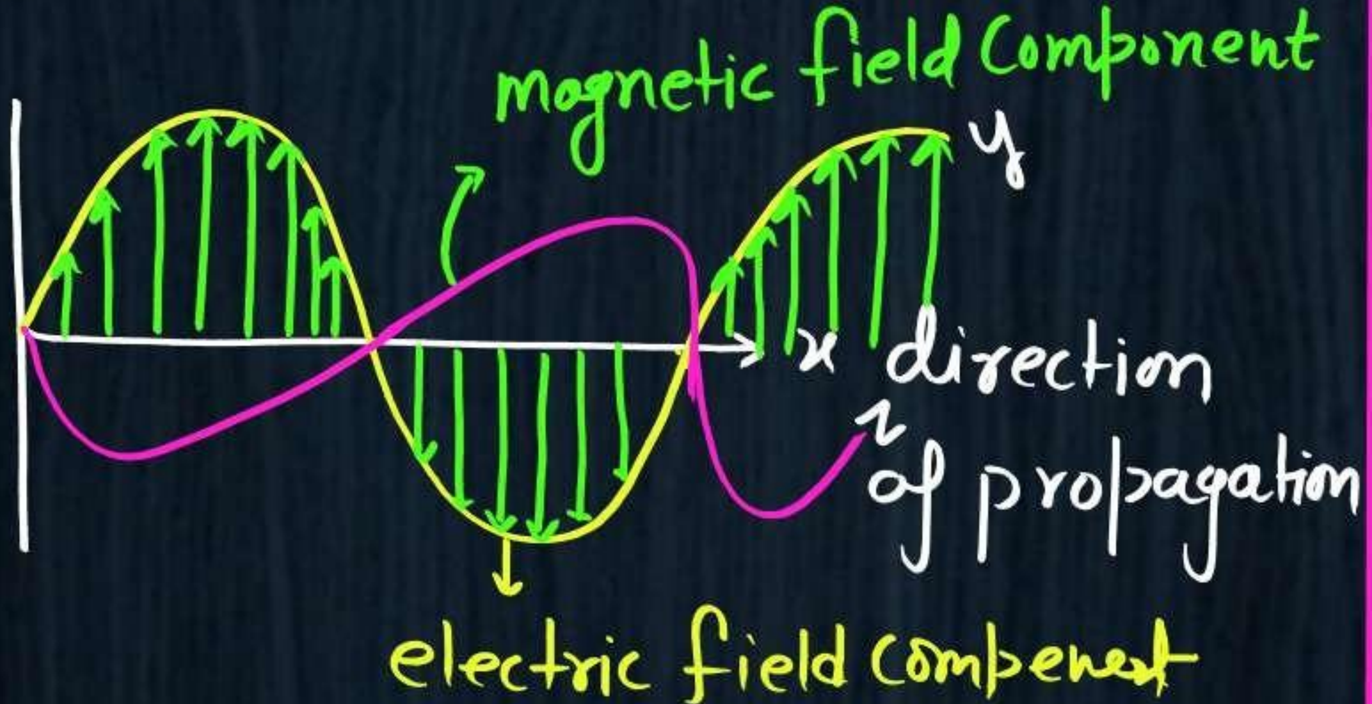
Dual nature of light

sun light ⟶ 2-nature ⇒

- {wave nature}
- {particle nature}



wave nature of light	particle-nature of light



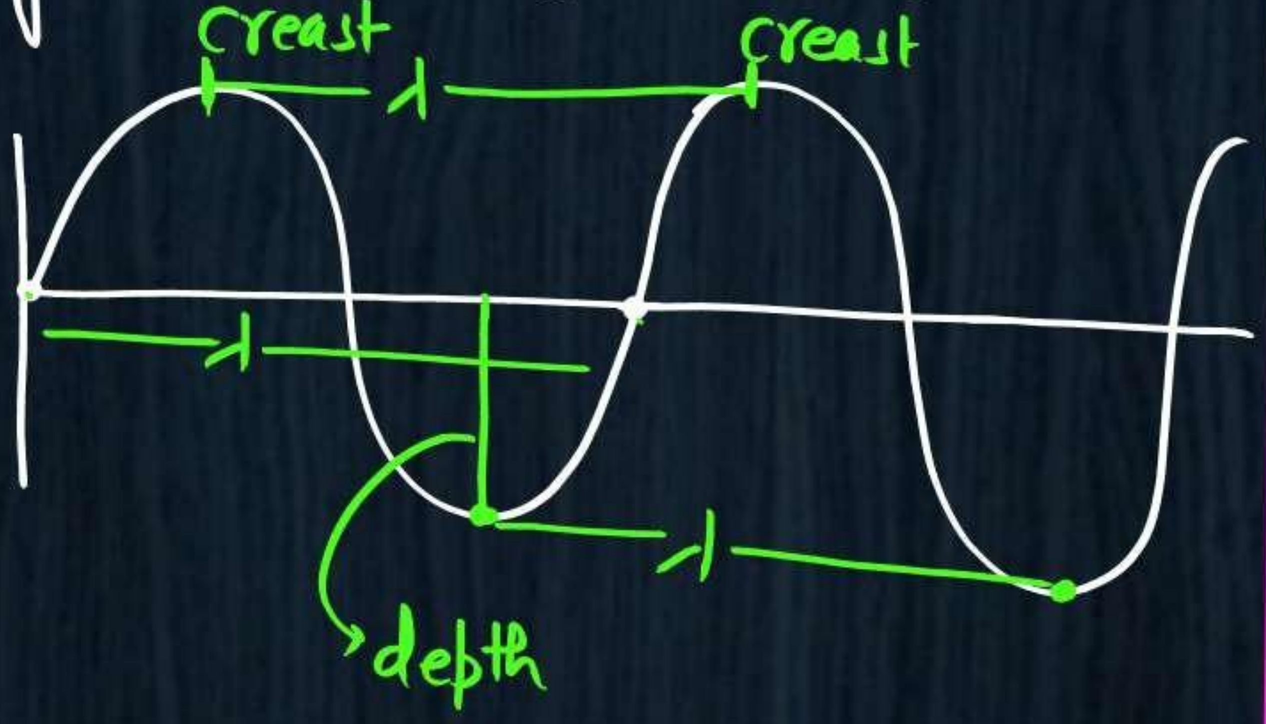
e.m. wave = electro-magnetic wave

propertie → wavelength
→ wave number
→ frequenuy

(plank's Quantum theory)

→ quanta ⇒ quanta = very small energy packet
– quanta
– quanta ⇒ in case of light, these quanta are called photon

Wavelength (λ) → length of single wave



Unit ⇒ $1\,\text{Å} = 10^{-10}$ m

$1\,\text{pm} = 10^{-12}$ m

$1\,\text{nm} = 10^{-9}$ m

symbol → λ

(2) Each quanta have energy

(3) $E = n h\nu$

Energy of quanta is integral multiple of $h\nu$

$E = n h\nu$, $E = h\nu = \frac{hc}{\lambda}$

$n = 1, 2, 3, 4 \ldots$

$n \neq 0$

$n \neq$ -ve

$n \neq$ fractⁿ

where → h = plank's const

$h = 6.626 \times 10^{-34}$ Joulesec

wave number ($\bar{\nu}$)

$$\bar{\nu} = \frac{1}{\lambda}$$

frequency (ν) = No. of wave pass through a point in 1 sec

$$\nu = \frac{c}{\lambda}$$

c → speed of light
λ → wavelength

$$c = 3 \times 10^8 \, m/sec$$

Q minimum energy of quanta is x Joule, the select the possible energy of other quanta

(a) $\frac{3}{2}x$ (b) $\frac{11}{2}x$ (c) $\frac{10}{3}x$

✓ (d) $3x$

Soln

$$E = nx$$

$n = 1, 2, 3, 4, \ldots \infty$

$C_{SD} = 5$

① $E = n \times h\nu$

$n = 1, 2, 3, 4 \text{ ---}$

② $E = h\nu = \frac{hc}{\lambda}$

$h = 6.6 \times 10^{-34}$ Joule Sec

$C = 3 \times 10^{8}$ m/sec

λ = wavelength of photon or quanta

Home work

No HW Today

Thank - You